Name of research institute or organization:

Physikalisches Institut, Universität Bern

Title of project:

Neutron monitors - Study of solar and galactic cosmic rays

Project leader and team:

Prof. Erwin Flückiger, project leader
Dr. Rolf Bütikofer, Dr. Benoît Pirard

Project description:

The Cosmic Ray Group of the Division for Space Research and Planetary Sciences of the Physikalisches Institut at the University of Bern, Switzerland, operates two standardized neutron monitors (NM) at Jungfraujoch: an 18-IGY NM (since 1958) and a 3-NM64 NM (since 1986). NMs provide key information about the interactions of galactic cosmic radiation with the plasma and the magnetic fields in the heliosphere and about the production of energetic cosmic rays at the Sun, as well as about geomagnetic, atmospheric, and environmental effects. They ideally complement space observations. The NMs at Jungfraujoch are part of a worldwide network of standardized cosmic ray detectors. By using the Earth's magnetic field as a giant spectrometer, this network determines the energy dependence of primary cosmic ray intensity variations in the GeV range. Furthermore, the high altitude of Jungfraujoch provides good response to solar protons ≥ 3.6 GeV and to solar neutrons with energies as low as ~250 MeV.

In 2008, operation of the two NMs at Jungfraujoch was pursued without major problems. No significant technical modifications were necessary. The recordings of the NM measurements are published in near-real time on the webpage (http://cosray.unibe.ch). Although it seems that Solar Cycle 24 has started in January 2008 with the first appearance of a reversed-polarity sunspot, the solar activity was extremely low in 2008. The monthly smoothed sunspot numbers where even lower than in 2007, and March/April 2008 marked the preliminary sunspot minimum. The mean yearly count rate of the IGY NM at Jungfraujoch in 2008 was about 0.5% higher than in 2007. The cosmic ray conditions near Earth were undisturbed during the whole year as can be seen from Figure 1, which shows the daily counting rates of the IGY NM for 2008. As a consequence of the low solar activity, no Ground Level Enhancements (GLEs), and no major Forbush decreases (Fd) were observed. The pseudo-periodic variations are mostly a consequence of the sector structure of the interplanetary magnetic field (IMF).

In 2008 the European Seventh Framework (FP7) project Neutron Monitor Database (NMDB) has started. In a test phase 12 NM stations including the Jungfraujoch NMs send data in real-time to a database server. The Bern group is developing a software package to determine the ionization and radiation dose rates in the Earth's atmosphere based on real-time NM data from the NMDB server.

In October 2008 the IGY NM at Jungfraujoch marked 50 years of operation. When the Swiss confederation decided to join the International Geophysical Year in 1957-1958, Prof. Friedrich G. Houtermans, head of the Physikalisches Institut of the University of Bern (1952-1966) proposed to build a NM at Jungraujoch. A promising

young student was entrusted with the construction of this detector: Hermann Debrunner, later head of the cosmic ray group at the University of Bern (1964-1997), director of the High Alpine Scientific Stations Jungfraujoch and Gornergrat (1964-1999) and president of the board of the International Foundation HFSJG (1973-1999). The IGY NM with 12 counter tubes was put in operation first on the roof of the building of the research station, and from August 1959 inside the Sphinx laboratory. In summer 1966 the detector was moved to today's position on the terrace of the Sphinx laboratory, and by adding six counter tubes it was enlarged to an 18-IGY NM.

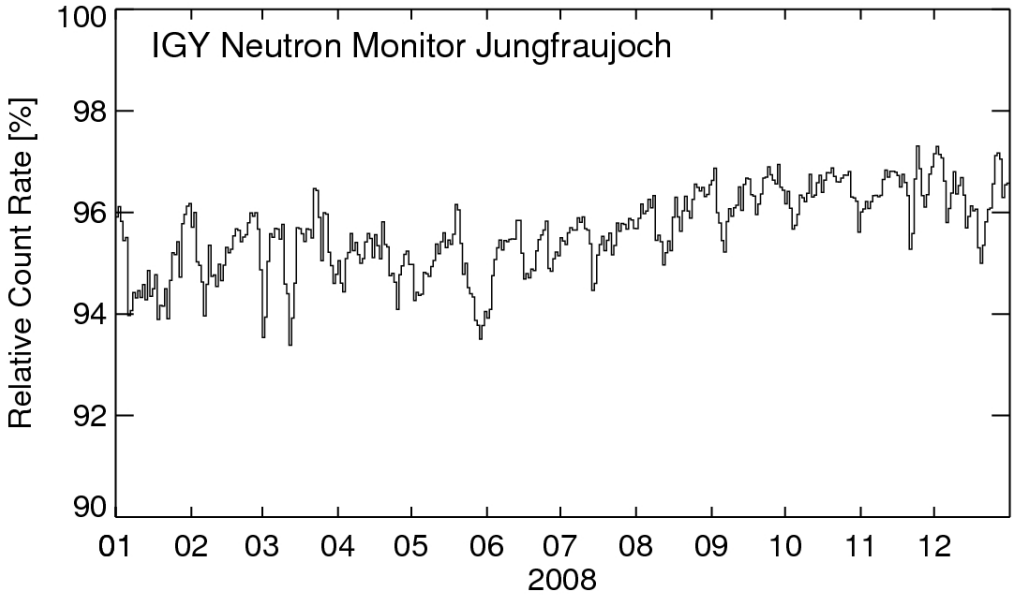

Figure 1: Relative pressure corrected daily counting rates of the IGY neutron monitor at Jungfraujoch for 2008.

Bieber et al. [Bieber, J.W., J. Clem, D. Desilets, P. Evenson, D. Lal, C. Lopate, and R. Pyle, Long-term decline of South Pole neutron rates, Journal of Geophysical Research, Volume 112, Issue A12, 2007] have shown that the 1997 peak rate of the South Pole NM was ~8% lower than the 1965 peak rate. However, this decrease was not observed at other South polar NM stations. In their investigations Bieber et al. therefore do not outrule detector tube aging as the reason for the decline in the count rate. If this hyposthesis is correct, a detector tube aging effect should also be present at the NM64 NM at Jungfraujoch, because the NM64 NM at Jungfraujoch has the same type of counter tubes and a similar counting rate per tube as the South Pole NM, i.e. 100 cts/second. Figure 2 shows the monthly values of the relative count rates of the Swiss NMs from the respective beginning of operation until November 2008. Only the IGY NM at Jungfraujoch of the Swiss stations has been in operation in 1965. The peak rate of the monthly mean count rate of IGY NM in 1965 was higher by 5.9% compared to 1997. The two European NM stations Kiel, Germany, and Oulu, Finland, recorded a decrease of 2.9% and 1.5%, respectively, in this time period.

For the time period 1985-2008 Figure 3 shows the monthly count rate ratio of the IGY and NM64 NMs at Jungfraujoch. It seems that the average count rate ratio

IGY/NM64 tends to increase by 0.12% per year after 1988. The steplike decrease in Figure 3 in 1988 was caused by a recalibration of a barometer. The partly well pronounced seasonal variations are due to snow accumulations on the roof and around the detector housings. At the IGY NM the custodians at Jungfraujoch remove the snow from the roof of the detector housing at least once a day. At the NM64 NM snow removal is not possible. Therefore the seasonal effect is more dominant in the data of the NM64 NM compared to the IGY NM. From our analysis we can at present time neither confirm nor exclude an aging of counter tubes over periods of decades.

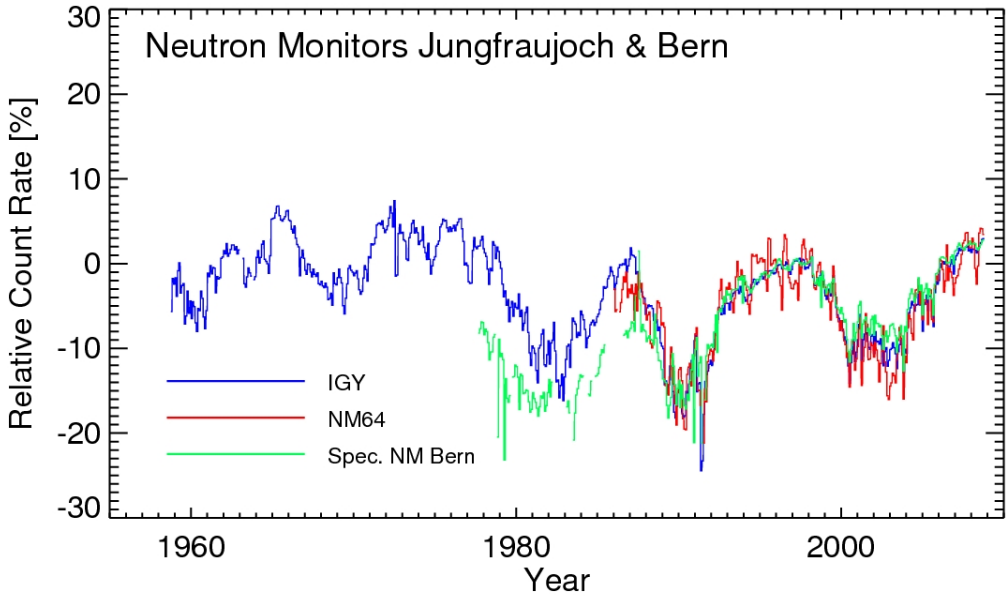

Figure 2: Monthly values of relative count rate of the three Swiss NMs from the respective beginning of operation until November 2008.

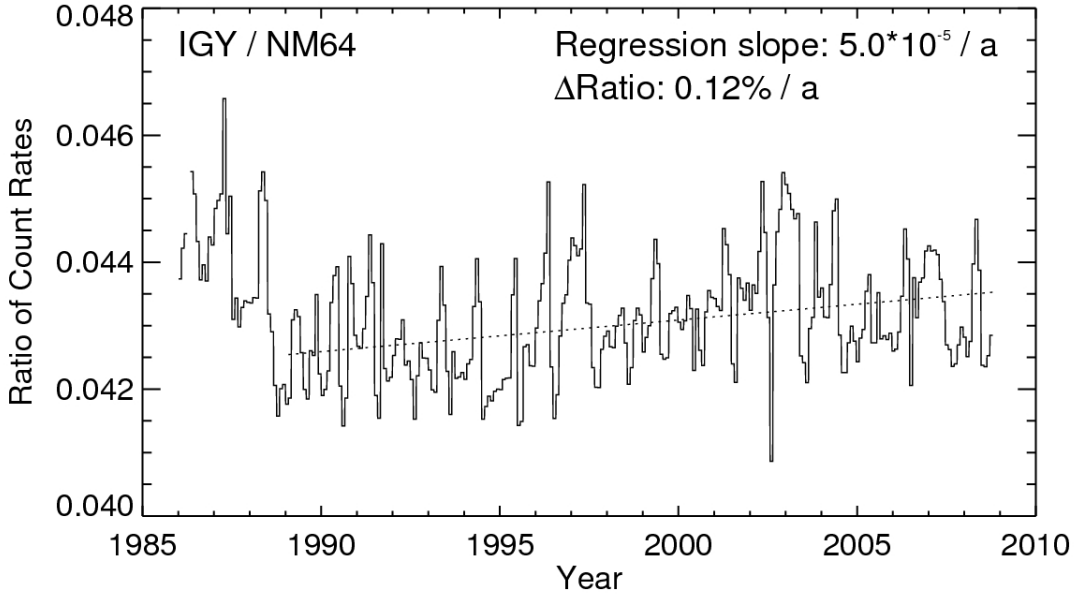

Figure 3: Ratio IGY/NM64 NM of monthly averaged count rates.

Key words:

Astrophysics, cosmic rays, neutron monitors; solar, heliospheric and magnetospheric phenomena

Internet data bases:

http://cosray.unibe.ch

Collaborating partners/networks:

International Council of the Scientific Union's (ICSU) Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)

World Data Centers A (Boulder), B (Moscow), C (Japan), International GLE database

European FP7 Project Real-Time Database for High Resolution Neutron Monitor Measurements (NMDB): http://www.nmbd.eu

Scientific publications and public outreach 2008:

Refereed journal articles

Flückiger, E.O., and R. Bütikofer, Swiss Neutron Monitors and Cosmic Ray Research at Jungfraujoch, accepted for publication in Advances in Space Research, 2008. http://www.elsevier.com/wps/find/homepage.cws_home

Book sections

Flückiger, E.O., and R. Bütikofer, Untersuchungen der kosmischen Strahlung auf Jungfraujoch – 50 Jahre Neutronenmonitore, «Mitteilungen der Naturforschenden Gesellschaft in Bern», **65**, 2008. http://www.ngbe.ch/content/default.asp?mid=4&rid=0&id=14&action=detail

Conference papers

Flückiger, E.O., The relationship of cosmic rays to the environment, 21st European Cosmic Ray Symposium in Košice, Slovakia, 9-12 September 2008.

Bütikofer, R., E.O. Flückiger, and B. Pirard, Effective radiation dose for selected intercontinental flights during the GLEs on 20 January 2005 and 13 December 2006, 21st European Cosmic Ray Symposium in Košice, Slovakia, 9-12 September 2008.

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